

9. Conclusions

In this chapter the major conclusions of the document are summarized in two general areas, namely current knowledge regarding appropriate complementary-feeding practices (section 9.1) and recommendations for further research (section 9.2).

9.1 Conclusions regarding appropriate complementary-feeding practices

The following is a summary of conclusions regarding appropriate complementary-feeding practices, based on the material presented in the preceding chapters. The conclusions are not intended to be used in isolation from the main text or for direct use by field workers. Mention of specific foods is for the purpose of illustration only. Individual programme guidelines need to be developed based on a thorough understanding of locally available foods and their composition. In some instances the following conclusions must be considered tentative until more information is available. In all cases, the conclusions assume that women have adequate support and opportunity to breast-feed their infants through at least the first year of life. When this is not the situation, some statements may need to be modified. It should be borne in mind that most foods appropriate as complements to breast milk are not equivalent to it, and cannot be considered adequate breast-milk substitutes. Non-breast-fed infants need a complete replacement diet, whose description is beyond the scope of the present review.

9.1.1 Age of introduction of complementary foods and appropriate duration of breast-feeding

The primary authors of this report are of the view that full-term infants with appropriate weight-for-gestational-age should be exclusively breast-fed until about six months of age. This conclusion is probably also appropriate for term infants who are small-for-gestational-age at birth (< 2 500 g), unless they are so underweight that they are too weak to suck or their mothers are severely malnourished. However, there are insufficient data from controlled interventions to permit definitive conclusions concerning these latter subgroups of children. If infants are too weak to suckle but are able to take oral feeding, they may be exclusively fed with breast milk expressed by their mothers. If mothers are severely malnourished, the conditions that produce maternal malnutrition also make artificial feeding very risky. It is preferable to correct the mother's nutritional status and support optimal breast-feeding than to provide breast-milk replacements. In cases of maternal malnutrition or low-birth-weight infants, micronutrient supplements may need to be provided to otherwise exclusively breast-fed infants or to their mothers before six months. More specific information is provided below (section 9.5). Because of the aforementioned conclusion regarding the appropriate age for introduction of complementary foods, this report focuses on complementary feeding from the age of six months onwards.

The current WHO recommendation concerning the desirable duration of breast-feeding

appears to be well-justified. Children should continue to be breast-fed for up to 2 years of age or beyond, while receiving nutritionally adequate and safe complementary foods.

9.1.2 Energy required from complementary foods and duration of need for special foods

The amount of energy needed from complementary foods depends on the age of the child and the quantity of breast-milk consumed. Based on current breast-milk intakes in developing countries, the average amount (and range) of energy required from complementary foods is approximately 275 (75-465), 450 (230-675), and 750 (490-1000) kcal_{th}/d for developing country children aged 6-8, 9-11, and 12-23 months of age, respectively. These figures should be used as general guidelines of the range of energy required from complementary foods, but the best indicator of adequacy will be the infant's growth.

Once complementary foods are introduced at about 6 months, special transitional foods (i.e. foods with semi-solid consistency and adequate energy and nutrient densities) are recommended. Most infants are able to consume chopped or mashed family foods by the end of the first year of life.

9.1.3 Energy density, frequency of feeding, and other factors affecting energy intake

Appropriate frequency of feeding depends on the usual energy density of complementary foods and vice versa. Based on theoretical calculations of gastric capacity, the following estimated minimum energy densities (kcal_{th}/g) of complementary foods are needed to satisfy energy requirements if 2, 3 or 4 meals are provided per day to children receiving average amounts of breast-milk energy (also see Table 14):

Minimum energy density (kcal_{th}/g) by number of meals

Age range (months)	2 meals	3 meals	4 meals
6-8	0.88	0.59	0.44
9-11	1.16	0.77	0.51
12-23	1.48	0.98	0.74

Breast-fed infants from 6-8 months of age should receive, in addition to breast milk, at least two or three meals per day, depending on the population's nutritional status and the likely energy density of complementary foods. Children older than 8 months should receive at least three meals per day. They would benefit from an even greater number of meals if the energy density of the diet is less than 1 kcal_{th}/g. Empirical data from non-

breast-fed, recovering malnourished infants indicate that greater energy intakes occur with each additional meal, regardless of energy density, but there appear to be diminishing returns in that, as the number of meals increase, the increment in total energy intake is progressively less. Thus, there is a limit beyond which meal frequency cannot compensate for low energy density. Recommendations regarding feeding frequency should take into account the potentially adverse effects of very frequent meals on breast-milk intake.

Low energy density often coexists with low nutrient density. Modifications to increase the energy density of complementary foods, such as adding lipids or sugar, must take into account the potential adverse impact on protein and micronutrient density.

The order in which complementary foods are fed to breast-fed children (i.e. before or after nursing) does not appear to have much influence on total daily energy intake, but long term effects on duration of breast-feeding have not been studied.

Flavour, aroma, consistency and variety may affect the intake of complementary foods. Amylase treatment can enable high energy and nutrient densities to be achieved at low viscosity. In some settings, viscosity reduction of diets of the same energy density has resulted in greater energy intakes, whereas in other settings no increase has been found. The reasons for this inconsistency are not understood, but may be related to differences in the viscosity and energy densities of the unmodified diets, the types of foods ordinarily consumed by the study subjects, or other methodological differences.

9.1.4 Macronutrients

Breast milk will meet the essential fatty acid requirements of exclusively breast-fed infants. However, care should be taken to assure that complementary foods contain enough essential fatty acids to meet requirements and enough fat to meet energy needs and to facilitate absorption of fat-soluble vitamins from complementary foods. The desirable fat content of complementary foods depends on the mother's breast-milk fat concentration, the infant's intake of breast milk, and the judgement of what is an acceptable guideline for the percentage of total energy from fat. If one accepts approximately 30% of total kcal_{in} from fat as desirable, complementary foods should contain approximately 0-13% of energy from fat at 6-11 months and 21% of energy from fat at 12-23 months, assuming that breast-milk intake is average and mothers have normal milk fat concentrations (Table 17).

Assuming that consumption of breast milk is average (see Table 7), the protein density (g/kcal_{in}) of complementary foods is not likely to be a limiting factor in most populations. However, this generalization may not hold where complementary foods are based on staples of low protein content, such as sweet potatoes or cassava. Amino acid needs from complementary foods were not considered in this report, but need to be reviewed in the future.

9.1.5 Micronutrients

Meeting micronutrient needs from complementary foods appears to be the greatest challenge. The estimates of required micronutrient densities of complementary foods are based on the presumed amounts provided by breast milk at different levels of milk consumption (Table 27). Based on the calculations regarding protein and micronutrients (see section 4.5), adequate amounts of certain key nutrients (iron, zinc, and calcium, in particular) can only be met if animal products are consumed in quantities unlikely to be feasible. Thus, alternative strategies, such as fortification or supplementation, need to be considered. It must be kept in mind that these estimates are based on theoretical calculations that may be amended by further empirical research.

In the case of malnourished mothers, supplements to the mother are advisable, particularly with respect to the "Group I" nutrients shown in Table 23 (thiamin, riboflavin, vitamins B₆ and B₁₂, vitamin A, iodine and selenium). When dietary supplements can be provided to malnourished mothers, they have the additional advantage of preventing further maternal depletion.

It is practically impossible to supply enough iron from unmodified complementary foods to meet calculated needs of an infant at 6-11 months of age without unrealistically high intakes of animal products. Key iron-rich foods are liver, fish and beef; eggs are also high in iron, but its bioavailability is questionable. The quantities of these foods that would be needed to meet estimated iron requirements are generally much higher than currently observed maximum intakes prior to 12 months in the few studies from which quantitative data are available. If estimated requirements are correct (this requires further research), other means of providing iron at this age are needed (such as fortification of complementary foods or supplementation). After the first year of life, it is theoretically possible to meet iron needs from foods such as liver (60-80 g/d), but the practicality of this in most populations is questionable. It is generally advised that low-birth-weight infants receive supplemental iron from about 3 months of age onward.

It is also very difficult to meet zinc needs from unmodified foods at 6-8 months, unless there is a high intake (totalling about 50-70 g/d) of liver, dried fish, milk powder, or beef. At 9-23 months, calculated zinc needs can be met by relatively high intakes of liver, fish, cheese, milk powder, beef, egg or chicken (50-200 g/d). Again, the practicality of such intakes of animal foods in many populations is questionable.

Calcium needs can be met if sufficient amounts of milk products or fish (including the soft bones) are consumed, the amounts being approximately 20-35 g/d of milk powder or dried ground fish at 6-11 months, and 12-20 g/d at 12-24 months. When milk is available and is the most accessible source of calcium and other nutrients, it should be boiled and preferably incorporated into complementary foods during cooking. Use of fluid non-human milk during infancy is not usually recommended for breast-fed infants because of the risks of displacement of breast milk, microbial contamination (particularly if feeding bottles are

used), and gastrointestinal blood loss when fresh milk is consumed.

For children whose mothers have normal breast-milk vitamin A concentrations (at least 50 µg/L), vitamin A needs can be met by appropriate selection of complementary foods. Good sources include liver, leafy greens, milk, eggs, cheese, and some orange or red fruits. For infants aged 6-11 months, the amounts of these foods required are not large (generally 1-50 g/d), in part because breast milk is a rich source of the vitamin. Further information is needed concerning the bioavailability of vitamin A precursors from green leafy vegetables and fruits. Where red palm oil or other local food sources of easily absorbable precursor carotenoids are available, vitamin A needs can be met readily.

In areas where vitamin A deficiency is endemic, improved provitamin and vitamin A intake by the mothers and/or greater intakes of vitamin A-rich complementary foods by their children is advisable. Vitamin A supplementation of mothers and/or their infants with an appropriate timing and dosage is an alternative.

9.1.6 Feeding behaviours

Interventions to improve complementary-feeding practices should include consideration of feeding style and child appetite, as they may influence the types and amounts of complementary foods consumed by young children. For example, poor appetite is a common phenomenon and can have a large impact on total energy intake. Therefore, it is important to provide caregivers with a variety of strategies for overcoming poor appetite, including more frequent feeding and using those foods generally preferred by the child.

Feeding recommendations that address intake during and after illness need to be included whenever complementary-feeding guidelines are developed. Caregivers should be supported in efforts to feed children effectively during illness and convalescence. For example, breast-feeding should be continued (or increased) during illness, as should other components of the usual diet if the child's appetite permits.

9.1.7 Food processing and food safety

Foods may be contaminated by heavy metals, pesticides and drug residues. Some foods contain anti-nutritional factors. Fortunately, most of these are heat labile or can be removed by physical separation of specific parts of the foods. Bacterial contamination of cooked foods may occur, particularly if stored at ambient temperatures. Traditional lactic acid fermentations inhibit the growth of certain pathogenic microorganisms, including *Shigella* and *Escherichia coli*, and remove some anti-nutritional factors. Specific types of food processing can enhance nutrient bioavailability. Appropriate processing techniques must be chosen depending on the types of foods, available resources, and the effects of these processing methods on nutrient content and bioavailability, and on consumer acceptance.

9.1.8 Intervention programmes

Intervention programmes can be designed to improve child-feeding practices (including breast-feeding and complementary feeding); enhance the energy and nutrient content of complementary foods; and/or ensure the microbiological and chemical safety of these foods. Enhanced nutritional value of complementary foods can be achieved by making specific food mixtures or individual foods more accessible - through centralized manufacturing and distribution or targeted food pricing strategies - or by providing appropriate educational messages to encourage and facilitate home preparation of acceptable food mixtures. Development of feasible interventions requires information on pre-existing feeding practices, available foods and local preferences.

A small number of well designed efficacy trials have been completed to assess the nutritional impact of small-scale complementary-feeding interventions. The results of these intervention studies have been inconsistent, for reasons that are uncertain. Where positive impacts on growth were identified, these were of greatest magnitude in younger children, especially those below 2 years of age. Several nutrition education interventions concerning complementary feeding have also been thoroughly evaluated. These projects found that it was possible to change child-feeding practices through a combination of interpersonal education and mass media, although the face-to-face counselling appeared to be most effective. In some cases, the changes in feeding practices were associated with small improvements in children's nutritional status. Few large-scale complementary feeding programmes have been evaluated with regard to nutritional impact.

9.2 Research recommendations

Before listing the specific types of new information that are needed most urgently for planning complementary feeding programmes, it is appropriate to make several general strategic comments concerning the implementation of these future research activities. First, because of the continuous progression of young children's physiological development and nutritional needs, research on complementary feeding must be focused on fairly narrow age ranges for the results to be interpretable. Second, because of differences in genetic background, available foods, exposures to infectious agents and other environmental factors in different settings, as well as the broad range of socioeconomic characteristics and cultural beliefs that influence child feeding, it will probably be necessary to conduct many of the following studies in more than one location to ensure the external validity of the results. For this reason, it would seem useful to create networks of research teams that are able to plan common research protocols and share relevant experiences and results.

After reviewing the limited number of evaluations of complementary feeding programmes, it was remarkable how little information has been collected from controlled trials designed to examine either the efficacy or effectiveness of different intervention programmes. One obvious conclusion of this review is the urgent need for carefully controlled evaluations

of complementary feeding programmes. Because of the desirability of conducting research that will eventually contribute to the design of novel intervention programmes, many of the research recommendations listed below will need to be carried out in several phases. For example, a particular line of inquiry, such as the impact of micronutrient fortification of complementary foods, may begin with assessment of technical (nutritional or food processing) issues, then proceed to formative research to adapt these general technical recommendations to local needs, and end with an evaluation of the impact of a controlled intervention programme. For this type of research to be successful, it will be necessary to establish interdisciplinary research teams capable of dealing with the full gamut of relevant technical, biological, social, and behavioural issues.

Specific suggestions for future research are listed in the following section under several general, and occasionally overlapping, categories.

9.2.1 Relationships between breast-feeding and complementary feeding

9.2.1.1 Age of introduction of complementary feeding

Additional information is needed, particularly from controlled intervention trials in different settings, on the optimal age of introduction of complementary foods. The impact of complementary feeding at different ages should be examined with regard to the following outcomes: total energy consumption and energy intake from breast milk and complementary foods, total micronutrient intake and micronutrient status, growth and development, morbidity, and maternal health, maternal nutritional status, and return to fertility. In the possible event that more prolonged exclusive breast-feeding is compatible with adequate infant energy intake and growth, but is associated with sub-optimal infant nutritional status with regard to selected micronutrients, different approaches to supplementing these critical nutrients (via the mother or directly to the infant) should be investigated. The effects of different times of introduction of complementary foods on infants' later food preferences, growth patterns, and speech development would also be of interest.

Future studies should also specifically examine factors that may affect the appropriate timing of introduction of complementary foods, such as maternal nutritional status, breast-feeding management (e.g. frequency of breast-feeds and practice of feeding to satiety on the breast), infant birth weight and gestational age. Relationships among maternal dietary intake and dietary supplementation, breast milk quantity and composition (with special concern for lipids and vitamins), and appropriate age of introduction of complementary foods should be studied in undernourished women.

Research is also needed on the consequences of the introduction of new foods on the physiology of the digestive tract (including the development of so-called tropical enteropathy and altered intestinal permeability), the profile of the intestinal microbial population, and the possible development of food allergies. Relationships between

subclinical malabsorption, and the physical growth and nutritional status of young children also need further examination.

9.2.1.2 Effect of complementary feeding on breast-feeding

Studies should be carried out on the effect of different complementary foods or fluids and the different methods of serving these (e.g. cup, plate and spoon, hand) on breast-milk consumption and duration of breast-feeding. The objectives of these studies would be to determine the possible risks of complementary feeding and the best ways of maximizing continued intake of breast milk. More information is also needed from both short-term and longer-term studies on the possible effects of the order of nursing and feeding complementary foods on the amounts of each (breast milk and foods) that are consumed by children of different ages.

9.2.1.3 Risks and benefits of continued breast-feeding beyond the first year of life

Evidence suggests that continued breast-feeding beyond 12 months is advantageous to infant health. However, some investigators have found associations between continued breast-feeding and poor child appetite or delayed growth, although the causal direction of these associations is uncertain. Rigorously designed longitudinal studies or intervention trials that can rule out confounding variables and reverse causation are needed to resolve these issues.

9.2.1.4 Reference growth data for breast-fed infants and young children

As previously recommended by the WHO Expert Committee on Physical Status (WHO, 1995a), a new growth reference is needed based on breast-fed infants and young children fed according to current global feeding recommendations.

9.2.2 Factors affecting intake of complementary foods and total daily energy intake

(Also see section 9.2.5 for influence of organoleptic factors on the consumption of complementary foods.)

9.2.2.1 Energy density and frequency of feeding

Studies are needed in various settings on the relationships among energy density of complementary foods, frequency of feeding, total daily energy intake, and energy intake from breast milk and complementary foods. Information is also lacking on the amount of different types of food that children of different ages, sizes, and nutritional status can consume at single and multiple meals (i.e. their "functional gastric capacity"). This latter information would provide an additional means of estimating the minimal required energy density of complementary foods.

9.2.2.2 Child appetite

The prevalence and etiology of poor appetite should be examined in different settings and possible preventive or therapeutic intervention trials should be conducted. The relationship between dietary monotony or diversity and total energy and nutrient consumption should be examined. More information is also needed on the frequency and causes of specific food aversions and possible forms of treatment.

9.2.2.3 Duration of need for special transitional foods

The age range when complementary foods need to be prepared especially for the child should be determined in different settings. This can be studied by examining food intake in relation to the type of food and food preparations provided to children of different ages, in different locations. Attention should be directed to both the physiological needs of the child at different ages and to any local cultural beliefs that dictate when a child is considered ready to consume different types and forms of food. Consideration should also be given to the range of other foods available in the household. Finally, the time required to feed different types of preparations should be measured.

9.2.3 Macronutrient content of complementary foods

9.2.3.1 Essential fatty acids

The essential fatty acid requirements of older infants and young children need further clarification, as does the ability of different local diets to meet these requirements. Information on the variability of the essential fatty acid concentration of human milk in different settings is needed to specify the amounts required from complementary foods.

9.2.3.2 Dietary lipids and absorption of fat soluble vitamins

Additional information is needed on the minimal amount of dietary lipid that is needed to assure adequate absorption of fat soluble vitamins from complementary foods.

9.2.3.3 Dietary lipids and palatability

The impact of dietary lipids on palatability and total energy intake from complementary foods and breast milk should be studied. Possible adverse effects of increasing dietary lipid concentration on the intake of protein and micronutrients should be explored.

9.2.3.4 Dietary lipids and chronic diseases

Possible relationships between early child-feeding practices and subsequent risk of cardiovascular and other chronic diseases should be explored, with special attention to the amount and types of dietary lipids.

9.2.3.5 Carbohydrate content of complementary foods

Because of their possible effects on palatability and satiety, the impact of different types of carbohydrates, such as dietary fibre, starches, and simple sugars, on total energy intakes from complementary foods should be studied.

9.2.3.6 Protein content of complementary foods

The ability of complementary foods prepared from low-protein staple foods, such as cassava and sweet potato, to meet protein requirements should be determined and possible ways of fortifying the protein content of these diets should be explored if necessary.

9.2.4 Micronutrient content of complementary foods and bioavailability of micronutrients

9.2.4.1 Intake and assimilation of micronutrients

Information is needed on the absorption and utilization of micronutrients from complementary foods and the effects of complementary foods on the assimilation of micronutrients from breast milk. Special attention should be directed to those nutrients, such as iron, zinc, calcium, and vitamin A, which are often consumed in limited amounts and may be absorbed relatively inefficiently from traditional diets.

Alternative approaches to improve the overall micronutrient content and bioavailability of local diets should be explored, including food fortification, domiciliary and commercial food processing (e.g. fermentation, germination, milling, and others), and increased use of animal products. The benefits of prenatal or postnatal maternal micronutrient supplementation and infant supplementation should be assessed. Other possible interventions to prevent iron deficiency during infancy should be evaluated. These include changes in obstetric practices related to timing of umbilical cord clamping; increased consumption of facilitators of iron absorption (e.g. ascorbic acid); and decreased consumption of inhibitors of iron absorption (e.g. phytates from cereals and legumes, and tannins from coffee, tea, or cereals). The relative costs and benefits of single versus multiple micronutrient supplementation or fortification should be compared.

9.2.4.2 Indicators of micronutrient status

Simple indicators of micronutrient status need to be developed, for individuals and populations. In particular, research is needed on the normal physiological changes in indicators of iron status and Vitamin A status during the first year of life to permit adequate assessment of nutritional status with regard to these nutrients. Ideally, this might include sensitivity and specificity analyses of various cut-offs for identification of deficiency and functional correlates of these indicators. Likewise, better indicators of zinc status need to be developed. The ability of dietary assessment instruments to predict

micronutrient status of populations should be examined.

9.2.5 Organoleptic characteristics of complementary foods

9.2.5.1 Viscosity

Descriptive information should be collected on the viscosity of traditional complementary foods given to children of different ages in representative households of different settings. The observed viscosities should be related to the ingredients used, the food preparation techniques, the mode of feeding, and the nutritional value of the final preparations. The possible influence of cultural beliefs on these food preparation practices should be explored. Viscosity should be measured by techniques that have been validated and standardized and whose results have been compared with those given by rotary viscometers. The ability of children of different ages and levels of neurological development to consume foods of different consistencies, and the time required for consumption of specified amounts of these foods, should be assessed. Further studies are needed, both from carefully controlled research units and from field settings, of the effect of different viscosities on energy intake from complementary foods and on total energy intake, as well as the time required for feeding. These outcomes should be investigated for children from 6 to 24 months of age in different populations and in relation to distinct levels of energy density.

9.2.5.2 Other organoleptic characteristics

The impact of other organoleptic characteristics, such as flavour, aroma, colour, texture, etc., on intake of complementary foods needs further elucidation.

9.2.6 Feeding behaviours

9.2.6.1 Caregiver characteristics and feeding techniques

Descriptive information is needed on child-feeding behaviours, such as the place, time, frequency of feeding and the style of feeding (e.g. active or passive, supervised or unsupervised). Factors that may influence these child-feeding behaviours, such as child temperament; the caregiver's autonomy, emotional well-being, knowledge and other personal characteristics; the number of small children in the family; and household resource constraints should also be examined. Simplified, reliable methods are needed to assess complementary-feeding practices.

9.2.6.2 Feeding practices and dietary intake

The relationships between child-feeding practices and children's intake of complementary foods and risk of food-borne infection need to be investigated. Likewise, the effect of feeding mode (cup, spoon, hand, self-feeding, other) on dietary intake and disease

transmission needs further elucidation. Research is needed on how best to identify and encourage positive feeding practices and to discover and modify harmful ones. Research is needed to assess whether interventions to improve the care-giving environment have an additive or synergistic effect when combined with other interventions to improve complementary-feeding practices.

9.2.7 Food processing and food safety

The effects of different food processing techniques should be evaluated with regard to their impact on nutritional value, microbiological quality, toxicology, and functional or organoleptic properties of complementary foods. Food processing and packaging methods of particular interest are milling, grinding, and fermentation of cereals and leguminous seeds; soaking, roasting, and/or toasting of leguminous seeds; solar drying; extrusion cooking; low-cost packaging (e.g. polyethylene bags); vitamin and mineral fortification; terminal cooking of fortified porridge and its effect on vitamin content; and methods of household storage post-cooking. The costs, risks, and benefits of different approaches should be assessed. Research is also needed on feasible methods for reducing viscosity, particularly using either home-produced or commercially prepared amylase.

9.2.8 Planning and evaluation of programmatic interventions

More experience is needed on optimal ways to adapt the current information to local intervention programmes. These include, for example, simplified methods to assess current infant and child-feeding practices and dietary intake; identification of feasible and appropriate ways of enhancing the existing feeding practices and dietary intake; development and communication of relevant educational messages; and production and distribution of centrally processed foods or ingredients to be added to the diets of young children. As stated above, controlled intervention trials are needed to assess the efficacy, effectiveness, efficiency, and costs of different approaches.